

**Hydroxylation and H<sub>2</sub> degassing in the lunar environment: Monte Carlo Studies,** O.J. Tucker<sup>1</sup> and W. M. Farrell<sup>1</sup>. NASA/Goddard Space Flight Center, Greenbelt, MD. (Orenthal.J.Tucker@nasa.gov)

We will examine the signature of surface hydroxylation using a statistical mechanics approach to model the degassing of solar wind implanted hydrogen atoms from the lunar regolith. Near-infrared observations by the Moon Mineralogy Mapper (M<sup>3</sup>) indicate there is a global distribution of OH, 500 – 750 parts per million (ppm), in the top meter of lunar soil [1]. We will present results from Monte Carlo simulations of this diffusive process and the subsequently derived H<sub>2</sub> exospheres.

Solar wind bombardment of the lunar soil both implants hydrogen atoms and produces a variety of atomic defects in regolith grains. This process is known to occur in experiments that measure diffusive rates from irradiated silica. The nature of the defects is not well understood. However, the diffusion rates can be well approximated using a distribution of activation energies. Farrell et al. (2017) showed a similar approach applied to the Moon could account for both the diurnal variations and populations of chemisorbed atoms observed in IR adsorption spectra [2].

We applied the Farrell et al. distributions to a test particle Monte Carlo method. The distribution of energies is represented using a Gaussian e. g.  $F(U_0, U_w) \sim \exp(-(U-U_0)^2/U_w^2)$  centered at  $U_0 = 0.5$  eV with a width of  $U_w = 0.1$  eV. At the 2018 Lunar and Planetary Science Conference, we showed results of surface concentrations from the Monte Carlo model that were quantitatively consistent with the global M<sup>3</sup> maps. The results were also consistent with exospheric observations of H<sub>2</sub> by the Lyman Alpha Mapping Projector on the Lunar Reconnaissance Orbiter [5].

Here we will present results from model studies that examine the effect of varying the width  $U_w$  of the activation energy distribution. At the equator from lunar morning to evening we obtain a  $V$  shape distribution of surface concentration with the minimum at local noon, and at higher latitudes where the surface is cooler the diurnal variation is milder. Our new studies examine the limits this approach by considering activation energy distributions for a range of widths e.g.,  $U_w = 0.075 - 0.125$ .

We will also consider the effects of both magnetospheric shielding and cold trapping. With our results we will estimate the change in surface concentration while the Moon is within the magnetotail and change of the global morphology of the surface content.

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**References:** [1] Li S. and Milliken R. E. (2017) Sci. Adv., 3:e1701471. [3] Farrell W. M. et al. (2017) J. Geophys. Res. Planets, 233, 269. [4] Tucker O.J. et al. (2018) Solar Wind implantation into lunar regolith II: Monte Carlo simulations of hydrogen retention in a surface with defects and the hydrogen (H<sub>2</sub>) exosphere. 49th LPSC. [5] Hurley D. M. et al. (2015) Icarus, 255, 159 – 163.